Economics Education and Research Consortium
Working Paper Series

Dollarization, Inflation Volatility and Underdeveloped Financial Markets in Transition Economies

Ruslan Piontkovsky

Working Paper No 03/02

This project (00-458) was supported
by the Economics Education and Research Consortium

Research area: **Macro, Financial Markets and Open Economy Macro**

JEL Classification: E52, F41

PIONTKOVSKY R.V. Dollarization, Inflation Volatility and Underdeveloped Financial Markets in Transition Economies. — Moscow: EERC, 2003. — pp 1–30.

The paper analyzes the phenomenon of dollarization in a sample of transition economies: Ukraine, Russia, Poland, Czech Republic, Romania, Slovenia, Croatia, Latvia, and Lithuania. Using the Thomas' portfolio balance model, the author tests how the degree of dollarization depends on the relative returns on financial assets, inflation volatility, and financial market development. The main conclusion from the analysis is that relative returns on assets (bank deposits in the domestic currency relative to deposits in foreign currencies) and inflation volatility have a significant effect on dollarization. The effect of financial market development is also captured, albeit indirectly, as dollarization is found to be dependent on the country's balance of trade (the inflow of foreign currency).

Keywords. Ukraine, Russia, dollarization, asset substitution, currency substitution, transition economies, portfolio optimization, inflation volatility.

Acknowledgements. The author is grateful to all participants of the EERC research workshops for their comments, especially to Victor Polterovich. Special gratitude is expressed to the Global Development Network and the International Monetary Fund for my scholarship in the IMF Research Department, which enabled me to discuss the research topic with Miguel Savostano, Eduardo Borensztein, Guilermo Calvo, and Patrick Honohan. Many thanks to Iryna Ivaschenko and Ihor Burakovsky for their interesting suggestions, and to Iryna Piontkivska — for her understanding and support in every stage of the project.

Ruslan Piontkovsky

National University of Kiev-Mohyla Academy, Kyiv
International Centre for Policy Studies, Kyiv
13–A Pymonenka Street, Kyiv, Ukraine 04050
Тел.: (+38044) 574 69 26
E-mail: ruslanp@eerc.kiev.ua

CONTENTS

> ... citizens of homeland keep saving dollars issued in the USA. And neither defaults with devaluations nor banking crises affect citizens' love for the best product of the U.S. paper industry. Quite the contrary — this love becomes even stronger.
>
> "*Izvestiya*", *March 15, 2000*

> Extending the Thomas paper to an environment where there are goods and capital markets imperfections would be one way of yielding an appropriate empirical specification on which to base tests of the importance of CS in LDCs.
>
> *John Caddington, 1989*

NON-TECHNICAL SUMMARY

A nation's currency is a key element of the independent monetary policy of that country. However, authorities can not force citizens to regard the currency they offer as the only money. In the 1990s, transition economies lifted restrictions on foreign currency holdings. At the same time, most countries underwent a prolonged period of macroeconomic instability. Partial dollarization of the countries in the region has been one of the consequences. In particular, households use the US dollar and euro (earlier — deutsche mark) for savings, for price setting and for payments for certain goods and services.

Traditionally, sharp devaluation of the national currency and related inflation are viewed as the main reason for dollarization. The nation's "own" money loses value so fast that people start looking for substitutes. These could be some goods and precious metals, but the most common substitute is the more stable currencies of other countries. In other words, when the purchasing power of the domestic money falls relative to foreign money, the share of foreign money in financial flows tends to increase.

This theoretical hypothesis has been tested and supported many times for many developing and transition countries. On individual countries, examples of other hypotheses regarding the factors of dollarization were tested. Often these hypotheses were not based on a theoretical basis.

In this paper I try to reveal one more common factor of dollarization for different countries — inflation volatility. Theoretically the link between dollarization and inflation volatility follows from Thomas' model. According to the model, with perfect financial markets and high international capital mobility, the level of dollarization depends on relative returns on assets in different currencies, return volatility (risk), and attitude to risk.

The source of risk in the model is price volatility in the country and abroad.

To test this hypothesis, I used data on 9 transition economies: 4 post-Soviet republics — Ukraine, Russia, Latvia, and Lithuania; and 5 post-socialist countries — Poland, Czech Republic, Romania, Slovenia, and Croatia. Taking into consideration that most of the countries' financial markets are poorly developed, I tried to account for different indicators of financial market development.

The most important conclusions of the empirical analysis are the following.

Relative returns on assets (deposits in different currencies) and inflation volatility are linked to dollarization in transition economies. Economic agents' choice of assets depends on their attractiveness (their return and risk characteristics). It is interesting that this result holds for countries with different monetary regimes: from a currency board (Lithuania) to direct inflation targeting (Czech Republic and Poland).

The estimation results imply that there is the potential to fight dollarization through the use of macroeconomic instruments such as high domestic interest rates, a predictable exchange rate, and a stable inflation rate. Targeting high interest rates is not a preferred instrument of economic (monetary) policy since high interest rates restrain the real economy. Predictability of the exchange rate and stability of the inflation rate can imply tradeoffs. For instance, keeping the exchange rate stable quite likely may result in higher inflation rate volatility. Therefore, inflation targeting seems to be a preferred instrument. In this case, possible exchange rate fluctuations could have no adverse effects on the relative return if financial markets are developed and interest rates reflect exchange rate dynamics and expectations.

The dollarization level in transition economies is not fully independent of foreign exchange flows as a means of payments. This statement is supported by the dependence of dollarization on the external trade balance. This relationship may indicate the relative underdevelopment of financial markets, because households and firms can not compensate external trade flows by means of financial instruments. Measures encouraging the development of financial intermediation and increasing its efficiency will contribute to weakening this relationship. However, I failed to find a statistically significant relationship between other indicators of financial market development and dollarization.

Dollarization in transition economies is quite inert. The long-run effects of dollarization determinants exceed the original short-run effects by a substantial factor, thus it is vain to expect immediate positive effects of the policies targeted at reducing the dollarization level in the country.

1. INTRODUCTION

The term dollarization is used to refer to the situation when residents of the country hold a share of their assets in the form of foreign currency and foreign currency denominated assets.[1] Dollarization consists of both currency substitution, when foreign currency is used for payments, and asset substitution, when foreign currency becomes mainly the means to store value. In the early 90s when the majority of post-socialist countries lifted restrictions on foreign currency holdings, they soon became significantly dollarized.

Among the reasons for fast growth in dollarization levels are asset diversification, an unstable macroeconomic environment, in particular, high levels of inflation and devaluation when national currencies cease to fully function as money, and undeveloped capital markets that provided no means for households and enterprises to invest savings. In this situation, the U.S. dollar and/or German mark and/or Russian ruble[2] made it possible to more efficiently perform transactions and store value, thus contributing to the welfare of private economic agents.

From the macroeconomic policy perspective, however, the existence of dollarization makes it more difficult for authorities to implement their goals. First, budget deficit financing, all other things being equal, becomes more inflationary because foreign currency replaces the national currency. As a result, covering the fiscal gap requires a higher monetary base growth. Second, the probability of a banking crisis increases provided there is a mismatch of assets and liabilities as well as a lower ability to pay off foreign currency borrowers, part of whose income is generated on the internal market. Third, the structure of dollarization —

[1] An alternative definition of dollarization is legislative introduction of a foreign currency as the official domestic currency. Following Calvo (1999), this phenomenon was called "complete" dollarization, which is different than the "partial" dollarization phenomenon referred to in this project. It is worth noting, however, that the political decision to implement complete dollarization is usually a consequence of the cost-benefit analysis of existing partial dollarization. The very term "dollarization" has become a common name and doesn't necessarily mean that the foreign currency used is U.S. dollars. It emerged when the observed phenomenon was actively analyzed in Latin America, where the dollar really was circulating as a parallel currency.

[2] Russian national currency is used as a foreign (parallel) currency in other post-Soviet transition countries although Russia itself is considered to have a significantly dollarized economy.

whether it represents more currency or asset substitution — makes more difficult the choice of an exchange rate regime and monetary aggregate as an operating goal of monetary policy. In general, the existence of dollarization makes the macroeconomic environment more risky.

The objectives of this paper are as follows: first, to test whether relative returns on assets, inflation volatility and financial market development are factors of dollarization in transition economies; second, to determine the implications of policies minimizing the negative effects of dollarization.

In the Thomas' portfolio balance model (1985), the level of dollarization depends on relative returns on assets, risks of assets and attitudes towards risk. My hypothesis is that the level of dollarization is negatively correlated with the development of domestic financial markets. Stylized facts described by Calvo and Vegh (1992) and Balino *et al*. (1999) provide evidence that the process of dollarization begins with substituting the function of money as a means of storing value, then — as a unit of account, and finally — as a medium of exchange (means of payment). It is assumed that in transition countries, in contrast to Latin American countries, dollarization has not widely reached the stage of currency substitution and represents mostly asset substitution. At the beginning of the transition period well-organized capital markets did not exist; that is why foreign currency became perhaps the only instrument to store value, and even presently remains one of the major instruments. At the same time, due to undeveloped financial markets, transaction motives (in particular, those related to external trade) significantly affect foreign currency portfolios of enterprises and households.

In this paper I test the following hypothesis, implied in Thomas' model, using panel data on 9 transition economies: the level of dollarization is determined by rate of returns and riskiness of assets denominated in national and foreign currencies, and attitudes towards risk. In addition, I test the relationship between the level of dollarization and financial market development.

The results of the empirical estimation of Thomas' model, augmented by financial market development indicators, allows me to make the following conclusions. First, relative returns on assets and inflation volatility are significant factors of dollarization in transition economies. This tentatively implies that high domestic interest rates, predictable exchange rates, and stability of inflation (not necessarily reduction of its level) might help "fight" dollarization. Second, the dollarization level in transition economies is not completely independent of transaction motives that are implied from its relationship with the external trade balance.

2. CONCEPTUAL FRAMEWORK

The literature on dollarization (currency substitution) is very multifarious. Theoretical models are based on different paradigms; empirical evidence based on the use of heterogeneous data and specifications often include ad hoc variables not included explicitly in theoretical models. Still, there is no consensus even concerning the definition of this phenomenon.[3]

The phenomenon of dollarization (currency substitution) has been studied since the 70s, and until recently research was concentrated mainly on developing countries of Latin America, where this phenomenon became the most significant.

In my opinion, there are three generations of dollarization (currency substitution) models. Early models (Calvo and Rodriguez, 1977; Leviatan, 1981) could not distinguish between the motives of currency and asset substitution because they assumed a choice from two assets only: domestic and foreign currency (that was a reasonable assumption at the time, because capital mobility was quite restricted). Residents maximize their real financial wealth w in a foreign currency:

$$W = M/E + M^*, \tag{1}$$

where M is domestic money, M^* is foreign money, and E is the nominal exchange rate.

The next generation of models — asset portfolio balance models — explicitly assumed the existence of bonds denominated in each currency. Demand for each asset, as defined by Branson and Henderson (1985), and Cuddington (1983),[4] is a function of real income and real return on each asset. In empirical studies usually only the domestic money demand function is estimated. For instance, Cuddington (1983) estimates

[3] The most often cited survey articles are Calvo and Vegh (1992), Giovanini and Turtelboom (1994), Mizen and Pentecost (1996). In this paper I follow Calvo and Vegh (1992) and (1996), defining currency substitution as a replacement of the medium of the exchange function of domestic money, while dollarization includes replacing the medium of exchange, unit of account and store of value functions.

[4] Other versions of the portfolio balance model are worth mentioning. In the sequential portfolio balance model (Miles, 1978), economic agents first choose the optimal portfolio of monetary and non-monetary assets and then decide on the structure of monetary assets. In the dynamic optimization model, Bufman and Leiderman (1993) use orthogonality restrictions that follow from first order conditions including money in the utility function. Mizen and Pentecost (1996) refer to these models as "restricted portfolio balance," while Branson and Henderson (1985) call them "unrestricted portfolio balance."

the following specification:

$$\log\left(\frac{M}{P}\right)_t = \eta_0 + \eta_1 r_t + \eta_2 (r^* + x)_t + \eta_3 \log Y_t + \eta_4 x_t + \eta_5 \log\left(\frac{M}{P}\right)_{t-1} + \omega_t , \quad (2)$$

where r — return on domestic bonds, x — depreciation rate of a domestic currency, $r^* + x$ — return on foreign bonds, y — real income. A significant coefficient η_4 indicates the existence of currency substitution, while coefficient η_2 indicates asset substitution.

The third generation of models — balance sheet models — consider dollarization from two sides of the financial intermediary (banks). In the model of Ize and Levy–Yeyati (1998), equilibrium dollarization fluctuates around the level of dollarization at which the whole portfolio has the minimum variance. Minimum variance of a portfolio's dollarization λ^* equals

$$\lambda^* = \frac{V(\pi) + Cov(\pi, s)}{V(\pi) + + V(s) + 2Cov(\pi, s)} , \quad (3)$$

where π — domestic inflation rate, a s — rate of the real exchange rate depreciation. From (3) it follows that the minimum variance of a portfolio's dollarization increases with inflation volatility, and decreases with the volatility of the real exchange rate. According to the model, equilibrium dollarization deviates from the minimum variance of a portfolio's dollarization in the presence of asymmetries between depositors' and borrowers' portfolios. These asymmetries arise when cross-border deposits are not matched by external loans, when the currency composition of bank reserves deviates from the minimum variance portfolio, and when financial intermediation in domestic and foreign currency is taxed at different rates. The model implies that an increase in depreciation expectations does not, by itself (unless agents revise their expectations of inflation and real exchange rate volatility), induce more dollarization and is only reflected in an increase in the internal interest rate differential. An important assumption of this model is the absence of foreign currency in circulation among assets.

This project is based on Thomas' (1985) theoretical model, which is considered as a second generation model. An investor chooses the quantity of domestic and foreign currency, taking into account transaction costs and interest rates, and then borrows and lends in each currency in order to optimize his or her currency portfolio. The model shows that currency substitution depends on nominal interest rates, while dollarization (cur-

rency substitution plus asset substitution) depends on the real return differential, assets' risk characteristics, and attitude to risk.

In my opinion, the model has the following advantages. First, in Thomas' model, the difference between currency and asset substitution is most clearly highlighted. For comparison, the model of Ize and Levy–Yeyati lacks this feature, as foreign currency in circulation is assumed not to exist, and their analysis is concentrated only on asset substitution.

Second, unlike balance sheet models, an estimation of Thomas' model does not require data on the currency structure of bank loans and reserves, information that usually is not published.

Third, there are few empirical tests of Thomas' model. Korhonen (1996) and Piontkivsky (2000) made an attempt to estimate Thomas' model empirically from data on transition economies. Korhonen (1996) tests the relationship between the dollarization level in Lithuania and the interest rate differential, and expected devaluation separately, while Piontkivsky (2000) tests the relationship between Ukrainian dollarization and the difference of real returns on domestic and foreign assets (where the interest rate differential and expected devaluation are combined into one variable). Both studies generally support the tested hypotheses, though Korhonen (1996) gets an insignificant coefficient of expected depreciation.

The key elements of the mentioned empirical studies are explicit or implicit assumptions of the constant risk of assets, and invariable attitudes to risk. If the latter seems to be more realistic, the former could appear to be too restrictive. It is a challenge to examine a more general version of Thomas' model by relaxing the assumption of constant risk of assets.

The disadvantage of applying Thomas' model to the analysis of transition economies is its assumption of perfect financial markets, where economic agents can borrow and lend on both domestic and international markets without constraints. This project tries to explicitly account for the impact of undeveloped capital markets on dollarization.

Undeveloped financial markets are mentioned in the literature as a cause of dollarization. Balino *et al*. (1999, 3, 24) stress that "dollarization reflects the absence of macroeconomic stability and the existence of distortions in financial markets" and recommends that "to limit dollarization, authorities may promote alternative financial instruments such as stocks, mutual fund shares, corporate finance bonds, and asset-backed securities". Mongardini and Mueller (1999, 21) claim that dollarization is "often driven also by the lack or thinness of markets for medium- and long-term securities denominated in the domestic currency" and in order to reduce dollarization, it is necessary "to pursue a

deepening of financial assets by lengthening the maturity of domestic securities, especially government bonds." Vetlov (2001) mentions the depth of the domestic financial market as one of the institutional determinants of dollarization. However, this idea is presented most precisely by Savastano (1996, 226):

> "The relative importance of foreign currency as an inflation hedge will be inversely related to the economy's level of financial development. An economy with a well-developed financial market is, in principle, capable of adapting rapidly to a high-inflation environment by offering a rich set of fairly liquid, high-yield instruments denominated in domestic currency ('near monies') that preserve the real value of the public's portfolio. In contrast, a 'financially repressed' economy undergoing high inflation generally offers domestic residents few options other than to seek protection in foreign-currency-denominated assets and instruments."

Literature on dollarization in transition economies develops also in other directions, although several years ago there were only a few studies on transition economies. The only survey article is by Sahay and Vegh (1995), who, in addition to providing a theoretical model, describe dollarization trends but provide no empirical estimations. Van Aarle and Budina (1995) estimate the currency substitution effect on seigniorage in the countries of Central and Eastern Europe.

Recently more and more researchers have expressed interest in this topic, and one possible reason for this is that dollarization is quite widespread in the region, and it is perceived to have a significant influence on economic activity and therefore economic policy. As a rule, authors test existing theoretical models using new data sets or look for dollarization determinants through the development of ad hoc models. Muller and Mongardini (1999) test the existence of hysteresis in Kyrgyzstan by including a ratchet-variable, *i.e.*, whether the current level of currency substitution depends on a previously observed maximum value. Sarayevs (2000) conducts econometric analysis of dollarization in Latvia, while Vetlov (2001) analyzes dollarization in Lithuania. Friedman and Verbetsky (2001) test the dynamic optimization model with money-in-the-utility-function on Russian data, while Shinkevich (2001) explains the high levels of dollarization in Russia and its hysteresis by the existence of network effects in demand for foreign exchange. Heimonen (2001) focuses on competition and the trade-off between the dollar and euro in currency substitution in Estonia.

3. MODEL SPECIFICATION AND ESTIMATION RESULTS

3.1. Theory and Model Specification

To determine the major factors of dollarization, we use Thomas' model (Thomas, 1985). A representative domestic consumer maximizes his or her expected utility by choosing real consumption level c and asset portfolio structure

$$\sum_{t=0}^{\infty} \beta^t u(c_t), \quad \beta \in (0,1), \tag{4}$$

where $u(c_t)$ — convex and increasing (von Neumann–Morgenstern function). The consumer chooses between 4 assets: domestic currency m, foreign currency f, domestic bonds d and foreign bonds b.[5] If

$$\theta_j (j = m, f, b, d)$$

is an asset's weight in consumer's wealth, then

$$\theta_f + \theta_b = \frac{f + b}{f + m + b + d} = DR$$

shows the dollarization level.

The consumer holds part of his or her assets in cash only because of its high liquidity. Domestic and foreign real money balances m and f reduce transaction costs presented as follows:

$$\begin{aligned} & s = cv\left(\frac{m}{c}, \frac{f}{c}\right), \\ & v \geq 0, v_{1,} \leq 0, v_2 \leq 0, v_{11} > 0, v_{22} > 0, v_{12} > 0, v_{vv} v_{22} - v_{12}^2 > 0, \end{aligned} \quad , \tag{5}$$

where s — shopping time. Additional real money balances yield positive though decreasing transaction cost reduction. Both money balances and bonds are imperfect substitutes.[6]

Thomas (1985) uses results from the continuous time portfolio allocation

[5] Here by bonds we mean any interest-bearing asset that does not provide liquidity services.

[6] Only in this case currency substitution may appear. If currencies are perfect substitutes, exchange rate indeterminacy results (see Kareken and Wallace, 1981).

model to derive the following first order conditions:

$$-v_1\left(\frac{m}{c}, \frac{f}{c}\right) = i\,, \tag{6}$$

$$-v_2\left(\frac{m}{c}, \frac{f}{c}\right) = i^*\,, \tag{7}$$

$$\theta_f + \theta_b = \frac{R^* - R}{A(V)(S^{*2} + S^2 - 2SS^*)} + \frac{S^2 - SS^*}{(S^2 - SS^*) + (S^{*2} - SS^*)}\,, \tag{8}$$

where i^* and i nominal foreign and domestic interest rate,

$R^* - R$ — difference of real returns on foreign and domestic bonds;

S and S^* — domestic and foreign prices' (instantaneous) standard deviations (SS^* —the covariance between them, S^2 and S^{*2} — variances);

$\mathrm{A}(V)$ —Arrow–Pratt measure of relative risk aversion.

As Vegh (1989) shows, (6) and (7) imply that the relative demand for money is determined by nominal interest rates i^* and i. The consumer keeps accumulating money assets until the cost of additional transaction services equals the cost of holding money (*i.e.*, nominal interest rate). Equation (8) shows that allowing for assets substitution (not only currency substitution), the optimal choice of the consumer will depend on the real return differential, relative return variance (risk) and attitude to risk.[7] As (8) implies, the optimal choice of the share of foreign currency denominated assets consists of a "speculative" component (the first item in (8)), and a "hedging" component (the second item), minimizing the risk of the portfolio's purchasing power. The source of risk in the model is price volatility in the country and abroad. As Thomas (1985, 351) pointed out, the "final structure of [the] net asset portfolio is independent on money demand".

In this project I suggest two approaches to the empirical specification, to be used to estimate Thomas' model. The first approach considers spe-

[7] Sahay and Vegh (1996) illustrate the difference between asset and currency substitution concepts with the following example. Assume the domestic nominal interest rate and speed of devaluation decrease by an equal amount. The real return differential does not change, therefore the dollarization level remains the same. Because the interest rate ratio changes, the structure of dollarization changes — a consumer holds less foreign currency, *i.e.*, currency substitution diminishes.

cial case (8), in which foreign prices are constant: $S^{*2}=0$. Therefore, $SS^{*}=0$ and $(S^{*2}+S^2-2SS^{*})=S^2$. Let

$$-(R^{*}-R)_t = i_t-(i_t^{*}+e_{t+1}^{e}) = RR_t \,[8]$$

— "net" relative return on domestic bonds. Then

$$DR_t=\frac{-RR_t}{A(V)(S^2)_t}+1 \quad \Rightarrow \quad 1-DR_t=\frac{RR_t}{A(V)(S^2)_t}. \tag{9}$$

In the case of stable foreign prices, the "hedging" component of a consumer's choice assumes holding all assets in a foreign currency (unity in (9)), and only a higher return on assets in the national currency adds to the "speculative" motive of the consumer to invest assets in the national currency. Thus, the equation to be estimated is as follows:

$$\Rightarrow \log(1-DR)_{it}=-\log(A(V))_i+\beta_1\log(RR)_{it}+\beta_2\log(S^2)_{it}+u_{it}. \tag{10}$$

From this it follows that $\beta_1=-\beta_2=1$. In addition, (10) does not allow for a negative relative return on assets in the national currency. We expect that an increase in the relative return on assets in the national currency increases its share in the portfolio, while an increase in inflation volatility reduces it.

The second approach considers a general case, the idea of which is to find a linear approximation of (8) — the level of dollarization as a function of relative return and inflation volatility — relaxing the restriction of price stability abroad. Assume that foreign prices change extemporaneously but its variance is constant. In this case simplifications (9)–(10) are impossible, and we have no well-defined specification following from the theoretical model. At the same time, the assumption of non-constant prices abroad is more realistic.

$$DR_{it}=f(A(V)_i, RR_{it}, S_{it}^2). \tag{11}$$

Thomas thought that his model was applicable to countries with open financial markets and high (international) capital mobility. In my opinion, this model is also applicable to transition countries if by capital mobility

[8] Strictly speaking, this formula is based on the assumption of (relative) purchasing power parity $\pi=e+\pi^{*}$, where π^{*} and π — inflation rates at home and abroad, e — devaluation rate of domestic currency.

we mean "internal/domestic" capital mobility — the possibility of free cross-flow between assets denominated in different currencies inside the country.

At the same time, we differentiate two groups of institutional factors which have a significant effect on the dollarization dynamics in transition economies: the existence of the "shadow" (unofficial) sector of the economy and relatively undeveloped financial markets. For servicing the "shadow" economy, economic agents actively use cash in foreign denominations. Such use of foreign currency could have a motive other than its return and riskiness, because these motives are dictated by the desire to keep financial operations off the official accounts. Since administrative authorities do not have full control over foreign currency circulation, foreign cash supports the functioning of the unofficial sector of the economy.

According to my hypothesis, the extent of financial market development affects the dollarization level through the following channels:

- Change of domestic asset portfolio risk characteristics. Let *d* consist of the set of assets *n* (mainly, bank deposits). As *n* increases — emergence of enterprises' stocks and bonds as well as government bonds — opportunities for domestic portfolio diversification increase. Then, in accordance with the Capital Asset Pricing Model (CAPM) (*e.g.*, Berndt, 1991), in the case of equal real returns variance of domestic portfolio decreases, and therefore, risk decreases;
- Banking system effectiveness: If banks offer new instruments allowing its clients to hedge off inflation and/or devaluation (*i.e.*, indexed deposits) or banking instruments become more flexible, then inflation volatility becomes less damaging, therefore, dollarization decreases;
- Because of limited opportunities to borrow, currency substitution and dollarization are not fully independent. That is why dollarization can depend on the external trade balance or current account balance since economic agents can not compensate for trade flows using financial instruments. For instance, when the trade balance is in surplus, there is a net foreign currency inflow into the country. Under conditions of developed financial markets, exporters could convert these monies into national currency to deposit them with local banks or to invest into securities or other instruments. Since their choice is limited and the secondary market is thin, the structure of exporters' portfolios depends on primary foreign currency inflow.

Therefore, in my opinion, inclusion of variables reflecting financial market development into specifications (10) and (11) could improve the explanatory power of the model.

3.2. Data

I use quarterly data for 9 transition economies — Ukraine, Russia, Poland, Czech Republic, Romania, Slovenia, Croatia, Latvia, and Lithuania.[9] Most of the data comes from IMF publication International Financial Statistics (IFS). The time series endpoints are 4Q2001, while the length of the series is conditioned on the beginning of their publication for each country in the sample (from the beginning of 1991 to the end of 1994). Uniform methodology of data composition allows cross-country comparisons. Fig. 1 shows dollarization dynamics in the sample countries.

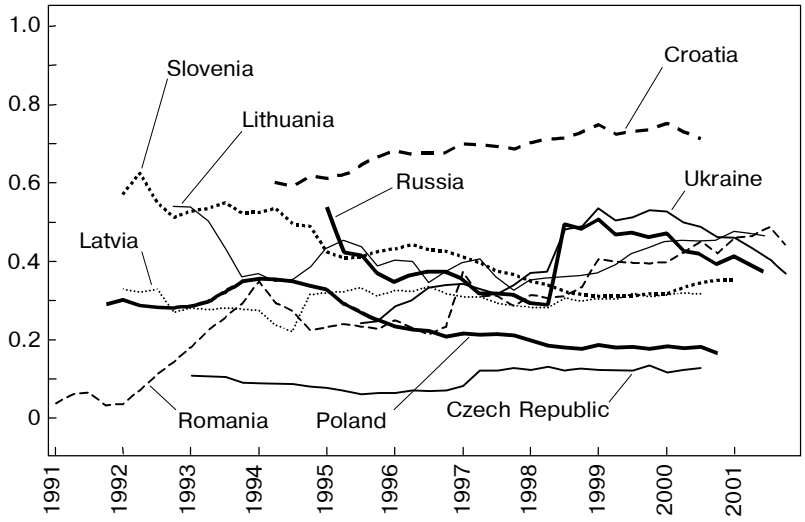

Fig. 1. Dynamics of the Dollarization Level in the Sample Countries.

Source: IFS, Central Banks of Poland, Slovenia, Croatia, Latvia, and Lithuania.

[9] Foreign currency deposits are available in International Financial Statistics only for 6 transition economies — Ukraine, Russia, Czech Republic, Slovak Republic, Romania, and Albania. This fact limits our sample. Albania was excluded due to political instability as was the Slovak Republic because of its particular features of foreign currency regulation. Poland, Slovenia, Croatia, Latvia and Lithuania were added to the sample because the data on foreign currency deposits at commercial banks were available from the web-sites of these countries' Central Banks. The source of data on interest rates on national currency deposits in Romania is the website of Central Bank of Romania.

The main problem with the data is the choice of the dollarization indicator. Theoretically, it should include the sum of foreign currency deposits, foreign currency in circulation, and foreign currency deposits of residents abroad (Balino, 1999), excluding deposits of non-residents in the country (Sahay and Vegh, 1996). I assume that the latter component is insignificant.

Taking into account the problem with statistics on foreign currency in circulation, I approximate the dollarization level (DR_{it}) by the ratio of the sum of foreign currency deposits in the country to the total volume of deposits (including those in the domestic currency),[10] that is

$$DR = \frac{b}{b+d}.$$

We can view this indicator as more appropriate compared to the ratio of foreign currency deposits to broad money

$$DR = \frac{b}{m+b+d},$$

since the effect of the shadow economy in the latter is reflected only in the denominator through national currency (cash) in circulation.

It is reasonable to assume that in the case of Ukraine, and especially Russia, omitting foreign currency in circulation from the dollarization ratio may seriously distort the series. That is why for these countries, I try to account for foreign currency in circulation on the basis of accessible data.[11] The dollarization indicator for Ukraine and Russia complies with

[10] Additional indicators of dollarization used in the study are the following: DRCB — the ratio of the sum of foreign currency deposits in the country and abroad to the total deposits; DRM — the ratio of foreign currency deposits in the country to the total deposits and national cash in circulation. Practical evidence shows that these indicators are highly correlated.

[11] Currently available data on foreign currency turnover are data on net purchase/sale of foreign exchange by households provided in households' income and expenditure statistics for Ukraine (starting from the third quarter of 1995). The author thanks Andrew Verbetsky for data on net foreign cash turnover in Russia (starting from the beginning of 1995). In order to include those data in the dollarization indicator, one should make an expert assumption of the size of the initial amount of foreign currency in Ukraine and Russia. I used the expert estimation of initial holding provided by Verbetsky and Friedman for Russia — $10 billions. I also assume that the initial amount of foreign currency in Ukraine equaled $1 billion.

its theoretical definition:

$$DR = \frac{f + b}{f + m + b + d}.$$

As a proxy for real relative return of domestic bonds

$$RR_t = i_t - (i_t^* + e_{t+1}^e).$$

I use the difference of the weighted domestic currency deposit rate and LIBOR on three-months deposits in U.S. dollar, taking into account expected devaluation (changes in average quarterly exchange rate of the domestic currency to the U.S. dollar).[12] I model three types of exchange rate expectations:

- Static expectations (this is used for calculating the real relative return's variable *RRSD*):

$$e_{t+1}^e = e_t;$$

- Adaptive expectations (this is used for calculating the real relative return, through variables *RRSD* and *DRM*(−1)):

$$e_{t+1}^e = \lambda e_t + (1 - \lambda) e_t^e;$$

- Perfect foresight (this is used for calculating the real relative return's variable *RRRD*):

$$e_{t+1}^e = e_{t+1}.$$

Inflation volatility indicator S^2 (which corresponds to variable VCPI in the econometric exercise) for quarterly data was calculated as a variance of monthly inflation levels (taking monthly CPI data).

I used the following indicators of financial markets development:

- national currency loan and deposit rates spread (*IRD* variable);

[12] A better definition is the difference of interest rates on domestic and foreign currency deposits. However, even if published, these data are available only for a shorter sample. For my proxy to be good, it is important that the dynamics of LIBOR and interest rates on foreign currency deposits be similar. Unfortunately, this condition does not always holds. For monthly 1996–2000 data on Poland, the difference fluctuated less than 1 percentage point (website of Poland's Central Bank), while in Ukraine in 1998–2000, the fluctuations reached 8 percentage points (National Bank of Ukraine' Bulletin).

- monetisation of GDP (*MONET* variable);
- external trade turnover (*TT* variable);
- external trade of goods balance (*TBG* variable);
- current account balance (*CA* variable).

3.3. Estimation Results

Tables A1 and A2 show Thomas' model estimation results of augmented specification equations (10) and (11) including financial development indicators. In particular, the estimated special case equation is as follows:

$$\log(1-DR)_{it} = \alpha_i + \beta_1 \log(RR)_{it} + \beta_2 \log(VCPI)_{it} + \beta_3 FMDEV + u_{it}. \qquad (12)$$

The general case equation is estimated in the following specification:

$$\log DR_{it} = \alpha_i + \beta_1 RR_{it} + \beta_2 \log VCPI_{it} + \beta_3 FMDEV + u_{it}. \qquad (13)$$

I present fixed-effects GLS estimates using unbalanced panel data.[13] Specification (13) is estimated on a data set including 237 observations, while specification (12) is estimated on a data set including 133 observations because of the restriction on the relative return indicator. The choice of generalized least squares is explained by data heteroscedasticity. To test for heteroscedasticity, I used the Breuch–Pagan test (Verbeek, 2000, p. 85). For 237 observations with 4 degrees of freedom, the Chi-statistic of null hypothesis equals 25.62. Since the value of the Chi-statistic exceeds the critical 5% significance value (9.48), I reject the null hypothesis of the absence of heteroscedasticity. I chose the fixed-effects approach because I assume that each country has characteristics which are not captured by independent variables. In particular, one such characteristic that follows from the theoretical model is attitude to risk. The extent of time-invariant risk aversion should be captured by fixed-effects.[14] In its

[13] I checked the sensitivity of the results for Russia and Ukraine to changes in expert estimates of the original volume of foreign currency. Table A3 shows estimation results for three cases: in addition to the basic assumption of USD 10mn for Russia I also used USD 5 billions and USD 15 billions assumptions. For Ukraine, besides the basic assumption of the original volume of USD 1 billions, I used USD 3 billions and USD 5 billions values.

[14] In special case specification (12), fixed-effects show different attitudes to risk, while in general case specification (13), they reflect different price volatility in other countries (abroad). The notion of price dynamics "abroad" may differ for each country because the structure of external economic relations is different (in particular, trade).

turn, risk aversion most likely depends on such factors as degree of central bank independence and history of inflation dynamics. That is why we expect different intercepts for different countries.

In both cases specification with adaptive expectations of exchange rate change performed better. However, in the case of adaptive expectations, the relative return indicator includes the current change of the exchange rate that also influences the formation of the dependent DR variable through the conversion of foreign currency deposits into units of national currency. That is why for the current change of exchange rate in the relative return indicator, I use exchange rate change in the next period as an instrument.

In both specifications, national currency loan and deposit rate spread, monetisation of GDP, external trade turnover and current account balance appear to be insignificant.

In the special case (12), lagged dollarization ratio and external trade balance have expected signs and 1% statistical significance, while relative returns has 5% significance. Inflation volatility has the expected sign but is insignificant even at the 10% significance level.

In general case (13), when the relative return enters the specification not in logs but in levels, all indicators appeared to be significant and had expected signs. The dollarization level exhibits high inertia; about 90% of its current value is determined by its past value. Short-term elasticity of dollarization to inflation volatility constitutes 0.6. At the same time, an increase in the relative return on assets in national currency by 1% leads to 0.3% reduction in dollarization level. An increase in the external trade balance by USD 100 mn leads to an increase in the dollarization level on average by 0.02%. Since I estimated the model with adaptive expectations, all corresponding long-run effects are about 10 times (1/(1−0.9)) higher than the short-run effects. In other words, the main part of the effect of parameter change is revealed as time passes.[15]

In order to test the stability of parameters, I excluded outliers[16] from the sample and re-estimated equation (13). Estimation results presented in Table A4 show that parameters remained practically unchanged. In other

[15] In particular, recently in Russia and Ukraine, the exchange rate has been exhibiting stability, and inflation has not been very volatile, but the dollarization level has changed very slowly. The estimation results do not contradict these observations because they show that the long-run effect significantly exceeds the original short-term effect.

[16] I excluded 23 observations.

words, the relationships are stable. Moreover, fixed effects appeared to be even more significant.

At the same time, as Verbeek (2000, 327–333) noted, if there is a lagged dependent variable on the right-hand side of the estimating equation, then estimations are biased. I solve this problem with the help of instrumental variables. I made an attempt to find instruments among financial market development indicators that turned out to be insignificant in regression (13). As one can see in Table A5, current account balance (CA) and monetisation level of GDP (MONET) appeared to be good instruments — their linear combination highly correlated with DR(−1) and simultaneously, they are practically uncorrelated with residuals of regression (13). Therefore, I estimate equation (13) as follows:

$$\log DR_{it} = \\ = \alpha_i + \beta_1 RR_{it} + \beta_2 \log VCPI_{it} + \beta_3 TBG + \beta_4 DR(-1)\_IV\_FIT + u_{it}. \quad (14)$$

In comparison with the estimation without instrumental variables, the effect of inflation volatility and of instrument remained practically unchanged. At the same time, the relative return coefficient almost doubled, while the trade balance effect appeared to be two times lower. This difference can be explained by the fact that equation (14) was estimated on a smaller sample because of the shorter series available.[17] Besides, the impact of the trade balance became insignificant, but it is most likely because it is highly collinear with the current account.

4. CONCLUSIONS AND POLICY IMPLICATIONS

The results imply the following conclusions. First, relative returns on assets and inflation volatility are factors of dollarization in transition economies. Economic agents' choice of assets depends on their attractiveness (their return and risk characteristics). This fact suggests that "internal" (intra-country) mobility of capital between different currencies is high. This result holds for countries with different monetary regimes: from currency board (Lithuania) to direct inflation targeting (Czech Republic and Poland).

Second, results of Thomas' model imply an alternative explanation of hysteresis. According to the model, the rise of relative returns on do-

[17] Romania was dropped, while the number of observations for Poland was significantly reduced.

mestic assets does not lead to a reduction in dollarization if it is accompanied with an increase in inflation volatility.[18]

Third, the estimation results imply the potential to fight dollarization through the use of such instruments as high domestic interest rates, a predictable exchange rate, and stability (not necessarily decline) of the inflation rate.

Targeting high interest rates is not a preferred instrument of economic (monetary) policy since (1) high interest rates may negatively affect the real economy, and (2) high interest rates result in redistribution in the dollarization structure towards currency substitution.

The predictability of the exchange rate and stability of the inflation rate can also imply tradeoffs. For instance, if by predictability of the exchange rate we mean its stability, and keep the exchange rate stable, it is quite likely that it may result in higher inflation rate volatility. Therefore, inflation targeting seems to be a more preferred instrument. In this case, possible exchange rate fluctuations could have no adverse effects on the relative return if financial markets are developed and interest rates reflect the exchange rate dynamics and expectations.

Fourth, the dollarization level in transition economies is not fully independent of transaction motives that are implied from its relationship with the external trade balance. This provides evidence of the relative underdevelopment of financial markets. Measures encouraging the development of financial intermediation and increasing its efficiency will contribute to the weakening of this relationship. However, I failed to find a statistically significant relationship between other indicators of financial markets development and dollarization.

Fifth, the long-run effects of dollarization determinants by a significant factor exceed the original short-run effects, thus it is vain to expect immediate positive effects of policies targeting the reduction of the dollarization level in the country.

[18] The explanation of hysteresis by inflation volatility does not contradict the explanation of this phenomenon related to an inactive band, fixed costs and network effects. Quite the contrary, considering inflation volatility as a dollarization determinant allows one to reduce the number of current "hesteresis" episodes, in which one should explain asymmetry.

STATISTICAL APPENDIX

Table A1. Thomas' Model Estimation Results by Generalized Least Squares: a Special Case.

Variable	Coefficient	Std. Error	t-statistic	Prob.
LOG(?VCPI)	0.005637	0.003690	1.527726	0.1292
LOG(?DR(−1))	0.890446	0.028343	31.41673	0.0000
LOG(?RRRD)	−0.010519	0.004922	−2.137006	0.0346
?TBG	4.36E−06	1.46E−06	2.998574	0.0033
Fixed Effects				
POL_--C	−0.166479			
RUS_--C	−0.291908			
ROM_--C	−0.127078			
UKR_--C	−0.124637			
LAT_--C	−0.110821			
LIT_--C	−0.097633			
CZE_--C	−0.304665			
CRO_--C	−0.043013			
SLO_--C	−0.103150			
Weighted statistics				
R-squared	0.986928	Mean dependent var		−1.408326
Adjusted R-squared	0.985621	S.D. dependent var		0.671723
S.E. of regression	0.080549	Sum squared resid		0.778578
Log likelihood	176.6411	F-statistic		3019.934
Durbin−Watson stat.	2.221928	Prob(F-statistic)		0.000000
Unweighted statistics				
R-squared	0.975439	Mean dependent var		−1.156219
Adjusted R-squared	0.972983	S.D. dependent var		0.495146
S.E. of regression	0.081386	Sum squared resid		0.794847
Durbin−Watson stat.	2.453607			

Dependent variable: LOG(?DR);
Method: GLS (Cross Section Weights);
Sample: 1992:1−2000:4;
Included observations: 34;
Number of cross-sections used: 9;
Total panel (unbalanced) observations: 133.

Table A2. Thomas' Model Estimation Results by Generalized Least Squares: a General Case.

Variable	Coefficient	Std. Error	t-statistic	Prob.
LOG(?VCPI)	0.006302	0.001626	3.876992	0.0001
LOG(?DR(−1))	0.920800	0.021911	42.02362	0.0000
?RRRD	−0.002911	0.000385	−7.558041	0.0000
?TBG	2.64E−06	1.04E−06	2.541863	0.0117
Fixed effects				
POL_--C	−0.110739			
RUS_--C	−0.182827			
ROM_--C	−0.094978			
UKR_--C	−0.069625			
LAT_--C	−0.084332			
LIT_--C	−0.054488			
CZE_--C	−0.200502			
CRO_--C	−0.026524			
SLO_--C	−0.073136			
Weighted statistics				
R-squared	0.984522	Mean dependent var		−1.348747
Adjusted R-squared	0.983693	S.D. dependent var		0.604033
S.E. of regression	0.077135	Sum squared resid		1.332766
Log likelihood	323.6722	F-statistic		4749.314
Durbin−Watson stat.	1.892914	Prob(F-statistic)		0.000000
Unweighted statistics				
R-squared	0.981115	Mean dependent var		−1.143093
Adjusted R-squared	0.980103	S.D. dependent var		0.548889
S.E. of regression	0.077424	Sum squared resid		1.342747
Durbin−Watson stat.	2.092270			

Dependent Variable: LOG(?DR);
Method: GLS (Cross Section Weights);
Sample: 1992:1−2000:4;
Included observations: 36
Number of cross-sections used: 9;
Total panel (unbalanced) observations: 237.

Table A3. Analysis of Results' Sensitivity to Experts' Estimation of Initial Foreign Currency Holdings in Russia.

	Russia, $10 mn		Russia, $5 mn		Russia, $15 mn	
	coef	prob	coef	prob	coef	prob
C	−0.18682	0.1505	−0.23024	0.1456	−0.15755	0.1709
LOG(VCPI)	0.023881	0.0135	0.024904	0.0263	0.022613	0.0086
LOG(DR(−1))	0.872324	0	0.862696	0.0002	0.871476	0
RRRD	−0.00318	0.0101	−3.28E−03	0.0281	−0.00301	0.0051
TBG	1.90E−06	0.7205	2.31E−06	0.7004	1.44E−06	0.7607
R-squared	0.857946		0.799328		0.886111	
Adjusted R-squared	0.824522		0.752112		0.859313	
S.E. of regression	0.074199		0.087442		0.065246	
Sum squared resid	0.093594		0.129984		0.07237	
Log likelihood	28.84152		25.22863		31.67048	
Durbin−Watson stat.	2.280829		2.232978		2.310208	

Table A4. Estimation Results by Generalized Least Squares for the Full Sample and Without Outliers.

	pool, 237 obs.		pool_no outliers, 214 obs.	
	coef	prob	coef	prob
LOG(VCPI)	0.006302	0.0001	0.005831	0.0002
LOG(DR(−1))	0.9208	0	0.894537	0
RRRD	−0.00291	0	−0.00404	0
TBG	2.64E−06	0.0117	2.84E−06	0.0073
POL_--C	−0.11074	0.0007	−0.15159	0
ROM_--C	−0.09498	0.0246	−0.12293	0.0033
UKR_--C	−0.06963	0.0152	−0.09804	0.0004
LAT_--C	−0.08433	0.0094	−0.11481	0.0002
LIT_--C	−0.05449	0.0198	−0.07052	0.002
CZE_--C	−0.20050	0.0014	−0.26641	0
CRO_--C	−0.02652	0.022	−0.04007	0.0004
SLO_--C	−0.07314	0.0032	−0.11953	0
RUS_--C	−0.18283	0.0007	−0.21838	0
R-squared	0.984522		0.988831	
Adjusted R-squared	0.983693		0.988165	
S.E. of regression	0.077135		0.075046	
Log likelihood	323.6722		312.6275	
Durbin−Watson stat.	1.892914		1.892468	

Table A5. Estimation Results by Generalized Least Squares for Specification with Instrumental Variables. Method: GLS (Cross Section Weights)

	Coef	Prob
LOG(?VCPI)	0.007197	0
?DR(−1)_IV_FIT	0.863161	0
?RRRD	−3.83E−03	0
?TBG	1.25E−06	0.1553
Fixed Effects		
POL_--C	−2.20E−01	0
RUS_--C	−0.188454	0.0002
UKR_--C	−0.114892	0.0001
LAT_--C	−0.149786	0
LIT_--C	−0.103714	0.0003
CZE_--C	−0.314599	0
CRO_--C	−0.049038	0.0002
SLO_--C	−0.143082	0
R-squared	0.986148	
Adjusted R-squared	0.985011	
S.E. of regression	0.073224	
Durbin−Watson stat.	2.104011	

Dependent Variable: LOG(?DR); Total panel (unbalanced) observations: 146.

	Coef	Prob
C		
?CA	2.89E−05	0
?MONET	0.000322	0
R-squared	0.959823	
Adjusted R-squared	0.957258	
S.E. of regression	0.174669	
Log likelihood	95.65647	
Durbin−Watson stat.	0.49945	

Dependent Variable: LOG(?DR(−1)); Total panel (unbalanced) observations: 151.

	Coef	Prob
?CA	−4.45E−06	0.0767
?MONET	−1.50E−05	0.6084
R-squared	0.051914	
Adjusted R-squared	−0.010827	
S.E. of regression	0.074162	
Log likelihood	207.9352	
Durbin−Watson stat.	2.228009	

Dependent Variable: RESID? Total panel (unbalanced) observations: 146.

REFERENCES

Van Aarle, B. and N. Budina (1995) Currency Substitution in Eastern Europe, Charles University Prague, mimeo.

Agenor, P–R. and P. J. Montiel (1999) *Development Macroeconomics* (Princeton: University Press).

Balino, T., A. Benett and E. Borensztein (1999) Monetary Policy in Dollarized Economies, *IMF Occasional Paper* No.171.

Berg, A. and E. Borensztein (2000) The Choice of Exchange Rate Regime and Monetary Target in Highly Dollarized Economies, *IMF Working Paper*, WP/00/29.

Berndt, E. R. (1991) *The Practice of Econometrics: The Classic and Contemporary* (Addison–Wesley Publishing Company).

Branson, W. H. and D.W. Henderson (1985) "The specification and influence of asset markets", in: R.W. Jones and P.B. Kenen, eds., *Handbook of International Economics* (North Holland, Amsterdam), 749–806.

Bufman, G, and L. Leiderman (1993) Currency Substitution Under Non-expected Utility: Some Empirical Evidence, *Journal of Money*, *Credit*, *and Banking* **25**, 320–325.

Calvo, G. and C. Rodriguez (1977) A Model of Exchange Rate Determination under Currency Substitution and Rational Expectations, *Journal of Political Economics* **85**, 617–625.

Calvo, G. and C. Vegh (1992) Currency Substitution in Developing Countries: An Introduction, *IMF Working Paper*, WP/92/40.

Calvo, G. and C. Vegh (1996) From Currency Substitution to Dollarization and Beyond: Analytical and Policy Issues, in: G. Calvo, *Money Exchange Rates*, *and Output*, (MIT Press), 153–175.

Cuddington, J. (1983) Currency Substitution, Capital Mobility and Money Demand, *Journal of International Money and Finance*, **2**, 111–133.

Friedman, A. and A. Verbetsky (2001) Currency Substitution in Russia, *EERC Working Papers Series* 01/05 (Moscow);
http://www.eerc.ru/publications/workpapers/WP_01-05r.pdf;
http://www.eerc.ru/publications/workpapers/WP_01-05e.pdf

Giovannini, A. and B. Tuttelboom (1994) Currency substitution, in: F. van der Ploeg, ed., *Handbook of International Macroeconomics*, (Cambridge, Massachusetts: Blackwell), 390–435.

Heimonen, K (2001) Substituting a Substitute Currency – The Case of Estonia, *BOFIT Discussion Papers*, 2001/11.

International Financial Statistics, (International Monetary Fund), various issues.

Ize, A. and E. Levy-Yeyati (1998) Dollarization of Financial Intermediation: Causes and Policy Implications, *IMF Working Paper*, WP/98/28.

Kareken, J. and N. Wallace (1981), On the Indeterminacy of Equilibrium Exchange Rates, *Quarterly Journal of Economics* **96**, 207–222.

Korhonen, I. (1996) Dollarization in Lithuania, *Review of Economies in Transition* **5**/96, 53–59.

Liviatan, N. (1981) Monetary Expansion and Real Exchange Rate Dynamics, *Journal of Political Economy* **89**, 1218–1227.

Miles, M.A. (1978) Currency Substitution, Flexible Exchange Rates, and Monetary Independence, *American Economic Review* **68**, 428–436.

Mizen, P. and E.J. Pentecost (1996) Currency Substitution in Theory and Practice, in: P. Mizen and E.J. Pentecost, eds., *The Macroeconomics of International Currencies: Theory*, *Policy and Evidence*, (Gloucestershire, Edward Elgar), 8–43.

Mongardini, J. and M. Johannes (1999) Ratchet Effects in Currency Substitution: An Application to the Kyrgyz Republic, *IMF Working Paper*, WP/99/102.

Piontkivsky, R. (2000) Dollarization Effects on the Macroeconomic Policy in Ukraine: The Case of Ukraine, paper presented at the International Conference "Cross-border Capital Flows in Transition Economies", Kyiv, April 12–13.

Sahay, R. and C. Vegh (1996) Dollarization in Transition Economies: Evidence and Policy Implications, in: P. Mizen and E. J. Pentecost, eds., *The Macroeconomics of International Currencies: Theory*, *Policy and Evidence* (Gloucestershire: Edward Elgar), 195–224.

Sarajevs, V. (2000) Econometric Analysis of Currency Substitution: A Case of Latvia, *BOFIT Discussion Papers*, 2000/8.

Savastano, M. (1996) Dollarization in Latin America: recent evidence and policy issues, in: P. Mizen and E. J. Pentecost, eds., *The Macroeconomics of International Currencies: Theory*, *Policy and Evidence* (Gloucestershire: Edward Elgar), 225–255.

Shinkevish, A. (2001) Dollarization Hysteresis in Russia, Final Report, submitted to EERC; http://www.eerc.ru/publications/e-prints/00-087E.pdf

Taylor, J. B. and M. Woodford, eds. (1999). *Handbook of Macroeconomics*, Vol. 1C, (Amsterdam: Elsevier Science B.V.).

Thomas, L. R. (1985) Portfolio Theory and Currency Substitution, *Journal of Money*, *Credit*, *and Banking* **17**, 347–357.

Turnovsky, S. J. (2000) *Methods of Macroeconomic Dynamics* (MIT Press).

Vegh, C. (1989) The Optimal Inflation Tax in the Presence of Currency Substitution, *Journal of Monetary economics* **24**, 139–146.

Verbeek, M. (2000) *A Guide to Econometrics* (John Willey & Sons Ltd).

Vetlov, I. (2001) Dollarization in Lithuania: An Econometric Approach, *BOFIT Discussion Papers*, 2001/1.